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## NOTES ON THE DESCRIPTION OF LAND FORMS.—V.

THE PLACE OF DEDUCTION IN THE DESCRIPTION OF LAND FORMS. It would appear from certain reviews in European geographical journals that there is an impression abroad to the effect that the use of deduction in geographical studies, particularly in relation to land forms, is an American innovation. If this were really the case, it would be highly complimentary to American and by no means flattering to European geographers; for inasmuch as the explanatory or evolutionary treatment of land forms is coming in these modern days to be more and more generally adopted as superior to any other means of treatment yet devised, and inasmuch as deduction is an essential process in determining the truth about the evolution of existing forms from earlier forms, it follows that the modern treatment of land forms cannot be successfully accomplished if deduction is ruled out. But it is by no means true that European geographers have neglected this important mental process. A good number of examples, some of which are briefly instanced below, might be cited to show a highly profitable use of deduction by well-known geographers of the Old World. Nevertheless, if international comparisons are to be indulged in, it may be admitted that deduction has been used less carefully and thoroughly, less consciously and intentionally, by many European geographers than by some American; and to just that extent is European treatment of land forms in danger of lagging behind American treatment.

But there is another aspect of this question which is often misapprehended by those European writers who do not consciously and habitually give deduction its merited place in their own studies. It seems sometimes, when along with other mental processes such as invention and comparison, deduction is given proper rank, that the European reviewer finds the importance thus assigned to deduction is much higher than that which it receives in his own studies, and he therefore names the whole method of investigation after this, to him, striking element. It would be more logical to name such a method of investigation the analytical method, since its essential quality is the close analysis of various possible solutions, and since in such analysis deduction is, as above noted, only one of the several mental processes that holds a necessary place. Again, it seems as if reviewers have sometimes assumed that the investigation of a geographical problem must have been largely deductive, because a deductive order of statement is employed in the presentation of the results; but this is by no means necessarily the case. The deductive method of presentation is so effective as a means of stating the results of an investigation to mature readers, that it may

be advantageously employed even if the results were reached largely by induction. It surely happens often enough that an observer, who has not had much occasion to employ deductive methods until after he has gained an abundant store of facts by outdoor observation, may nevertheless prefer to open the statement of his final results by announcing them as deductions from the general principles that he has established in good part by induction; and he may only on a later page substantiate his deductions by adducing appropriate examples of actual occurrence.

A sufficient reason for the choice of the deductive method of presentation for mature readers is that it is more concise and more easily understood than any other explanatory method. It is therefore desirable to distinguish between deduction employed as a method of exposition and deduction employed as a means of investigation; and furthermore to recognize that deduction, skilfully employed, aids in giving the valuable quality of clearness to exposition, just as deduction appropriately applied and guarded, aids in giving the invaluable quality of safety to an investigation. Whether deduction characterized the process of investigation as well as that of presentation in the following examples from German sources, cannot be immediately determined; but wherever it entered the treatment of the problems under discussion, it was evidently a helpful and powerful aid to the other mental faculties that were employed.

One of the most famous European examples of the use of deduction is that by v. Richthofen on the production of *Abrasionsflächen*, first presented in connection with his observations in China in 1870; afterwards in his "Führer für Forschungsreisende" (Berlin, 1886, 353-364), in which this highly esteemed geographer independently reproduced the deductive discussion regarding plains of marine denudation which Ramsay had given about twenty years before (Denudation of South Wales. *Mem. Geol. Surv. Gr. Britain*, i, 1846). Both of these able and original thinkers surely had abundant facts, geological and geographical, in mind; yet both employed a largely deductive method in setting forth the consequences of the hypothesis of marine planation. Neither of them, however, considered the alternative hypothesis of normal subaerial planation; neither of them therefore could substantiate their conclusions by showing that the plains, which they regarded as of marine origin, had all the appropriate features which such plains ought to have, and none of the particular features which plains of normal planation ought to have. But in this respect Ramsay and v. Richthofen were like some of their successors who, in discussing the possibility or normal planation with respect to the general baselevel of the ocean, overlooked the possibility of arid plantation independent of the ocean as baselevel, until this important theoretical consideration was introduced by Passarge. Evidently then the danger involved in the explanatory description of land forms does not lie so much in the use of hypothesis and deduction as aids in reaching explanation, as it does in the failure to employ invention of

hypotheses and deduction of consequences actively and thoroughly enough to rule out the chance of error. If there is any one lesson regarding the use of deduction that is to be drawn from the work of pathfinders like Ramsay and v. Richthofen regarding the genetic treatment of land forms, it is that deduction ought to be employed even more thoroughly and freely than they employed it.

A careful and conscious use of deduction is seen in Philippson's "Beitrag zur Erosionstheorie" (*Pet. Mitt.*, xxxii, 1886, 67-79), in which a conscious effort is made to study out deductively the nature of the slope to which a river valley will be reduced by indefinitely long-continued, uninterrupted erosion, and from which concrete cases are intentionally excluded in order to give sufficient place for theoretical considerations. Philippson here wisely examines so artificial a case as that of a smoothly sloping land surface of uniform structure, that is supposed to have been suddenly laid bare from the sea (76), and proceeds to deduce the changes that it will suffer under the action of consequent streams (although he does not call them by this handy name); and he is fully justified in doing so, because this simplified ideal case serves him as an excellent beginning from which more complicated natural cases are afterwards approached. The importance of weathering, creeping, and washing of soil in the reduction of interstream areas to faint relief in the late stage of an uninterrupted normal cycle of erosion is, however, underrated, and the importance of the lateral swinging of rivers in the production of subaerial plains is somewhat exaggerated in other writings of this author; but on the other hand Philippson has elsewhere briefly presented an extremely valuable deductive view ("Zur Morphologie des Rheinischen Schiefergebirges," *Verhandl. XIV. deut. Geogr'ntages*, 1903, 193-205. V. p. 199-) as to the possible dissection of a normal peneplain without its being elevated from the position in which it was formed; for inasmuch as a peneplain a thousand miles or more inland from the ocean must stand at a significant altitude above sea level, its rivers will be revived and its surface will be sharply dissected by the revived rivers, if the region between the peneplain and the ocean is depressed, all the better if the intermediate region is submerged so as to bring the shore line against the fault scrap or monoclinal slope by which the undisturbed peneplain is then bordered. This important principle has not been sufficiently recognized by those American geographers who, following the brief hints of Marvin (U. S. Geol. and Geogr. Surv. Territories, *Ann. Rep.* for 1873, 1874, 144) and the fuller discussions by Powell ("Exploration of the Colorado River of the West," Washington, 1875, 212), have deductively developed the conditions under which peneplains should be formed, and who have universally regarded the dissection of a peneplain as proof of its elevation. An application of Philippson's principle may be found in articles by Cvijić on peneplains in the Carpathians ("Entwicklungsgeschichte des Eisernen Tors. *Pet. Mitt., Ergänzhft.* 160, 1908; v, p. 52-; Also:—"Peneplains und epirogenetische Bewegungen der Sudkarpathen. *Pet. Mitt.*, liv, 1908, 114-116);

but neither Philippson nor Cvijič has deducted or otherwise indicated means of determining the share that the possible elevation of the peneplains themselves may have had, when conjoined with the depression of seaward lands, in causing dissection. Deduction of special consequences for each of these possibilities is therefore still to be desired.

No more striking example of the value of deductive treatment in a geographical problem can be found than that afforded by Passarge's brief discussion of *Rumpflächen und Inselberge* (*Zeitschr. deut. geol. Gesellsch.* lvi, 1904, *Protokoll* 193-209. See also:—"Die Inselberglandschaften im tropischen Afrika." *Naturwiss. Wochenschr.*, iii, 1904, 657-665). Here for the first time is clearly set forth the remarkable possibility—strangely overlooked by previous students—that a desert region of interior drainage may be reduced to a plain, truncating all manner of structures indifferently, by the combined action of arid weathering, winds, and occasional rains; and that the plain will stand at no definite altitude in relation to sea level. True, the conditions demanded for the realization of extensive desert levelling are peculiar, and probably exceptional in the earth's history; for they include the persistence of an arid climate over a very large continental mass which must stand undisturbed for geological ages. Nevertheless, Passarge's deduction of his consequences from his premises seems to be correct, whether his actual examples in South Africa are correctly interpreted or not. His use of deduction is made manifest by such phrases as:—"Nehmen wir also an," . . . "Voraussetzung ist, dass" . . . and "Welches wären voraussichtlich die Folgen gewesen?", as well as by the repeated use of the auxiliary verb, *müssen*, which has no place in the record of observational studies. Of course, arid planation may also take place with respect to the normal baselevel of the ocean in desert regions which slope to the sea; but even if some or all of the arid plateaus of Africa should eventually prove to be of such lowly origin, afterwards uplifted, instead of having been produced as interior plains at their present altitude, as Passarge supposes, the value of his deductions regarding the general processes and results of arid planation must hold good. Indeed, in view of their great success and importance, one must wish that he, an experienced explorer of desert regions, had himself more fully deduced and explicitly stated the expectable earlier stages of the arid cycle in their orderly progress toward arid planation, and that he had not left to a geographer of less experience in the observational study of desert lands the deductive elaboration of the youthful stage of many independent basins of centripetal drainage and central aggradation; of the early mature stage of integrated drainage, in which the higher independent basins of youth come to be tributary to a main lower basin where heavy aggradation takes place; of the late mature stage in which exportation of dust by the winds degrades the main basin faster than it is aggraded by inwashed waste; and of the stage of old age, in which even the main basin of heaviest aggradation has been swept

clean, and a flat rock floor developed far and wide, here and there veneered with a thin wash of gravel and sand, or interrupted by surviving Inselberge.

MOUNTAIN PASSES. Studien über Gebirgspässe mit besonderer Berücksichtigung der Ostalpen. Versuch einer Klassifikation. Von Dr. Johann Sölch. (*Forsch. z. deut. Landes-und Volkskunde, Stuttgart*, xvii, 1905, 119-273). This comprehensive essay forms an excellent example of the intentional and careful use of the deductive method for the presentation of the results of a geographical investigation. There is internal evidence that the accumulation of observed facts and the formation of induced generalizations accompanied, if they did not precede, the deduction of a systematic sequence of ideal examples; but to repeat in a published essay the necessarily irregular progress of an investigation, with many alternations between induction and deduction, would be an extremely ineffective method of acquainting the reader with the results reached by the writer. A deductive order of statement was therefore advisedly chosen; but it is accompanied and followed by the citation of many facts of actual occurrence, by means of which the correctness of the deductions is fortified.

The essay opens with a well-considered chapter (127-135) on the concepts implied by the term, pass, which shows that it may be employed simply to denote an element of form, a mere notch in a mountain crest never traversed by human foot, as well as in the more special anthropogeographical sense of a depression in a mountain range through which a single path or road connects a number of roads that converge toward the mountain base from the lower lands on either side. The second chapter (136-145) gives an empirical statement of the morphology of mountain passes: in the opinion of the reviewer this might have been well replaced by an explanatory summary at the end of the essay. Then comes the main body of the work, a discussion of the origin and development of mountain passes, in which deduction occupies an advantageously prominent place. A special section is given to a consideration so abstract as "die konstruktiven Gebirgspässe" (146-152), in which the effects of deforming a smooth surface by folding and faulting are elaborately set forth. A definite preparation is thus made for two following sections on "die fluviatilen Destruktionspässe" (153-195) and "die glazialen Destruktionspässe" (194-263). In the first of these two sections special attention is given to the gradual modification of constructional or initial passes by the action of ordinary or normal destructive processes, including weathering and creep as well as stream erosion; farther on, the relation of passes to the erosion of unsymmetrical divides, and to various kinds of river captures, is elaborately deduced (162-), the progressive change of form with the advance in an imaginary cycle of erosion being systematically set forth. Under the second heading, the importance of glacial erosion in deepening pre-existing notches and in producing new ones is explained with much detail. Notches in the back wall of enlarged cirques (Karpässe, 195) belong here; as do also those broad, flat-floored trough passes ("glaziale

Transfluenzpässe," 206), produced by heavy glaciers that overflowed preglacial divides and wore them down to more open form. Preglacial notches that have been deepened by the overflow of glacial distributaries ("glaziale Diffluenzpässe," 243) are also shown to be of importance. Numerous examples are cited, chiefly from the Alps. Had Sölch's essay had better page headings and paragraph headings, its abundant material would have been more easily read; and had it been illustrated by simple diagrams of type forms, its value would have been greatly increased.

TERRACES IN SOUTH-CENTRAL ITALY. A. Galdieri. *Le terrazze orografiche dell' alto Picentino a nord-est di Salerno*. (Boll. Soc. Geogr. Ital., xxix, 1910, 37-116). The author of this welcome contribution to the geography of Italy is a member of the Geographical Institute of the University of Naples. He opens his essay by saying that, as here for the first time a group of river terraces in southern Italy is illustrated, it appears desirable to depart somewhat from the usual method of scientific presentation—[whatever that may be]—and to make his account as elementary as possible, avoiding overabundant technical terms of difficult meaning. He therefore devotes a few introductory lines to recalling the familiar principles regarding the tendency of water to wear down the lands, and adds a brief explanation of the origin of terraces by the lowering of a river level, whereby the remnants of its former valley floor remain as lateral benches, which as erosion progresses become more extensively eroded and less easily recognizable. He then devotes 15 pages to the narrative and inductive description, with half-tone illustrations, of a series of rock benches, overlaid by heavy gravel beds, 50-75 m. in thickness, which now stand above the valley bottom of the upper Picentino, rising up stream from 220 to 250 m., and with much patience demonstrates that they are indeed terraces of the kind indicated at the opening of his essay. Six more pages are next given to the inductive demonstration of the existence of a still higher and more dissected group of gravel-covered terraces; and after this, "without further delay in other minute observations and superfluous demonstrations," brief mention is made of a narrow and discontinuous terrace at a much lower level than the first one mentioned. Not until the 23d page of the essay does the reader find a simple cross-section, on which the relative position of the three groups of terraces is concisely figured. Had this simple diagram been placed at the beginning, and had the items of fact been presented as related to the middle, the uppermost, and the lowest terrace, the reader would have been greatly aided in acquiring the writer's meaning. Still further aid would have been given if, following the introductory use of the diagram—and following also, if desired, an explanatory exposition of a simple deductive scheme, whereby terraces at successively lower levels and of less breadth may be produced—explicit statement had been made that the uppermost terrace consists only of much dissected lateral remnants of a wide-floored, late mature valley, above which the un-

terraced mountains rise in subdued forms; that the middle terrace represents a deeper valley which was somewhat less maturely widened; while the narrow strips of the lowest terrace indicate a still deeper valley which was only sub-maturely opened; and the present valley, incised beneath the lowest terrace, is comparatively young. Unfortunately this simple generalization is not explicitly announced, although it is graphically shown in the helpful but belated cross-section.

The omission of so illuminating a generalization can hardly be because its terminology is too difficult for the readers to whom the essay is addressed, but rather because of the habitual diffidence of European writers regarding the use of generalized or deductive phrases for the prompt presentation of their results at the beginning of their essays. Deduction is, however, abundantly used in the later pages of the essay, when, after showing that terraces similar to those of the upper Picentino occur in neighboring valleys, the origin of the terraces is discussed in some detail. The effects of land movements, of depression of sea level, and of change of climate are considered; the consequences of each possibility are determined deductively, and the success of each supposition is measured by the degree of accordance shown when its consequences are confronted with the appropriate facts. Evidently, then, as far as this essay represents an approved European method of presentation, deduction is an essential element in it, but this indispensable mental process is used chiefly in discussion after exposition has been completed, rather than as an aid in exposition itself.

As to the results gained by Galdieri from the deductive examination of the several hypotheses of terrace formation:—It is concluded that the climatic changes associated with the successive epochs of the glacial period were primarily responsible for the alterations between erosion of the valley floors and deposition of the heavy gravels upon them. Land movements are regarded as of subordinate importance. A distant reviewer, not acquainted with the ground, must not venture to criticize the application of this conclusion to the special case of the Picentino; but he may point out that, in so far as the deductive discussion of the problem is concerned, it would demand a very strong climatic change to cause, in a river of moderate length, the deep erosion of new valleys beneath the broadly opened rock-floor of a first formed, *late mature* valley, unless land movement acted as an important contributory cause. It would seem, indeed, as if the stage of valley development, as represented by width rather than by depth of valley floor, had received insufficient consideration in the deductive discussion as well as in the introductory exposition of the Picentino problem.

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